Jour. Agric. Res. China (中華農業研究) 43(2) : 123~134 (1994)

Genetic Analysis of Leaf Length and Width of Flag Leaf in Rice[1]

Yih-Chuan Kuo and Charng-Pei Li[2]

Abstract : Since some distinguished differences in leaf characteristics were observed between the modern U. S. and oriental rice cultivars and leaf length and leaf width are remarkable leaf characteristics in modern rice breeding programs, a series of genetic studies was designed to tackle the genetic control of leaf characteristics for expanding the genetic diveristy. Genetic information about leaf length and width of flag leaf reported here was deduce by the components of variation and the ratios between components and diallel graph from a six-parent diallel cross of rice, according mainly to theory and analysis of diallel cross of Hayman. Results clearly indicated that both additive and dominance gene effects were important in differentiating the two flag leaf characteristics; however, it is evident that the genetic mechanisms of two characteristics studied were different. As to leaf length, dominance gene effects was significantly greater than those of additive, the overall measure of dominance of leaf length was overdominance, and the direction of dominance was ambidirectional. On the other hand, dominance gene effects on controlling leaf width was unimportant than additive gene effects, the mean degree of dominance of leaf width was partial or incomplete, and the direction of dominance was toward relatively wider flag leaf.

Key words : Genetic, Leaf length and width, Flag leaf, Rice.

INTRODUCTION

Rice is primarily a tropical and subtropical crop, although rice is widely distributed in more than 100 countries on every continent except Antarctica and the best grain yields are obtained in temperate regions such as the Po Valley, Italy (45° N); northern Honshu, Japan (38° N); Korea (37° N); and New South Wales, Austrilia (35.5° N) (De Datta, 1981 ; Juliano, 1985). With such a wide range of cultivation conditions, it is no surprising that a lot of rice varieties have been cultivated that are adapted to varied environmental conditions.

Considerable attention has been paid to the relationship between yielding ability and

1. Contribution No. 1713 from Taiwan Agricultural Research Institute.
2. Respectively, Rice breeder and Research assistant, Department of Agronomy, TARI., Wufeng, Taichung, Taiwan, ROC.

morphological characteristics (Yoshida, 1972) due to Tsunoda's pioneering work in which he compared high and low yielding rice varieties (Tsunoda, 1959a; 1959b; 1960; 1962). The close association between certain morphological characteristics and yielding ability had led to the plant type concept as a guide for breeding high yielding cultivars (Jennings, 1964; Donald, 1968; Mock and Pearce, 1975; Donald, 1987). Although the judgment of desirable characteristics is based on physiological considerations, the plant type concept had proved extremely effective for breeding high yielding *indica* rice cultivars at the International Rice Research Institute in the past decade (Yoshida, 1972).

Among several leaf characteristics associated with high yielding ability, elect leaf habit seems the most important. In general, leaf length is much more variable than leaf width, and leaf length is closely association with leaf angle. The longer the leaves, the more droopy the leaves. As a result, short and small leaves are associatied with elect leaves. Theoretically, short and small leaves can be more evenly distributed than long and large leaves in a canopy ; more even distribution of leaves should increase the use of incident light by a canopy. Therefore, leaf length and leaf width are remarkable leaf characteristics in the modern rice breeding programs (Yoshida, 1972).

Compared to the modern oriental rice cultivars, the leaf characteristics, including physiological and morphological, of U. S. rice cultivars are quite different from the oriental rice (Tu *et al.*, 1988). Introduction to the oriental of modern U. S. rice cultivars for expanding the genetic diversity of newly developed local cultivars has encouraged the oriental rice scientists to elucidate the genetic control of leaf characteristics, and vice versa. Since leaf length and leaf width, with regard to leaf dimension, are remarkable leaf characteristics in the modern rice breeding programs and in general, the leaf width of U. S. cultivars is relatively wider than that of the oriental cultivars, the detailed genetic information about leaf length and leaf width from the crosses between the U. S. and oriental rice cultivars is important in presenting a thoughful breeding program. However, little is known about the genetic information on both leaf length and leaf width, according to the review of Chang and Li (1980). They pointed out that both leaf length and leaf width showed a nearly normal distribution in some crosses, but also indicated complex gene interaction in the other crosses. A series of genetic studies was, therefore, conducted to elucidate the detailed genetics of leaf characteristics. In the present paper, genetic mechanism of both leaf length and leaf width of flag leaf of rice are presented by using a diallel cross technique, according manily to the theory and analysis of Hayman (1954).

MATERIALS AND METHODS

A total of six rice entries, Rexmont, Lemont, Toro II, CI 9902, Guichow, and Taichung Sen 10 (TCS 10), representing a wide range of length and width of flag leaf, was seleected as the parents in this experiment. Of them, Rexmont and Lemont are improved typical U. S. southern long-grain rice cultivars; Toro II is a conventional U. S. southern long-grain rice varirty; CI 9902 is a promising long-grain rice germplasm; Guichow, a high yielding *indica* cultivar, released from the Rice Research Institute, Guangdong Academy of Agriculture

Science, PRC. under a breeding program with high yielding as a priority; TCS 10, a high yielding Chinese *indica* cultivar, released from Taiwan, ROC. under a breeding program with high yielding and quality. Crosses, including reciprocals and selfings, were made between the six parents in accordance with a diallel scheme. The 30 F_1 hybrids together with the six parents were grown in a flooded peddy field at the Texas A&M University Agriculture Research and Extension Center near Beaumont, Texas, in a randomized complete block design with three replications in 1990 (May to October). Each block consisted of 36 four-row plots. Each plot included 48 plants spaced at 30×30 cm. The leaf lenghts and leaf widths of flag leaf of twenty plants from the two central rows were measured in mm basis, based on an individual plant basis. However, their mean values for the two flag leaf characteristics, as presented in Table 1, had been transformed into a cm basis and were then used to calculate the genetic parameters of the flag leaf characteristics studied.

Table 1. Mean values of two flag leaf characteristics of the parents (diagonal) and F_1 hybrids in the six-parent diallel cross of rice.

Flag leaf characteristic	Female array	Male array					
		P_1	P_2	P_3	P_4	P_5	P_6
Leaf length (cm)	Rexmont(P_1)	22.30	27.90	22.20	21.05	31.58	23.07
	Guichow(P_2)	27.73	24.68	29.35	24.75	27.25	31.72
	Lemont(P_3)	21.52	28.43	26.83	20.57	29.35	22.10
	CI 9902(P_4)	22.28	26.83	24.40	20.10	26.12	23.92
	TCS 10(P_5)	28.85	27.00	31.42	25.73	28.57	31.53
	Toro II(P_6)	22.75	30.17	23.82	22.78	29.43	25.02
Leaf width (cm)	Rexmont(P_1)	2.00	1.98	1.91	1.79	1.91	1.82
	Guichow(P_2)	1.99	1.41	1.86	1.71	1.42	1.78
	Lemont(P_3)	2.01	1.90	1.94	1.85	1.85	1.73
	CI 9902(P_4)	1.95	1.76	1.85	1.56	1.70	1.61
	TCS 10(P_5)	1.98	1.44	1.91	1.73	1.38	1.80
	Toro II(P_6)	1.96	1.80	1.74	1.68	1.71	1.60

The analysis of data measured was based on the diallel technique of Hayman (1954) and Mather and Jinks (1971) by using a PC software created by Dr. C. Liu, Professor, Department of Agronony, National Taiwan University, Taipei, Taiwan and operated by Mr. S. F. Lin, a staff member of the Institute. Narrow-sense heritabilities for the flag leaf characteristics presented were calculated with the genetic components of variation according to the formula defined by Crumpacker and Allard (1962). Standardized deviations of the flag leaf characteristics were computed by following the formula of Johnson and Aksel (1959).

RESULTS AND DISCUSSION

Two flag leaf characteristic values, leaf length, and leaf width, of the six parents and their F_1 hybrids in the six-parent diallel cross of studied rice are summarized in Table 1. It was clearly revealed from Table 1 that a wide range of variation in the two flag characteristics studied were observed. Analysis of variance of randomized complete block design was, then, performed for the flag characteristics (Table 2). As shown in Table 2, there were highly significant differences among treatments which indicated the presence of genetic variability in the entries. A detailed analysis of Hayman diallel tables was, therefore, appropriate.

Table 2. Analysis of variance of two flag leaf characteristics of rice.

Source of variation	Degree of freedom	Mean square	
		Leaf length	Leaf width
Block	2	7.47	0.002
Treat.	35	35.83**	0.094**
Error	70	3.11	0.005
Total	107	—	—

** Significant at the 0.01 probability level.

Genetic interpretation deduced form components and ratios of variation

The genetic interpretation of data from a Hayman diallel analysis is valid only if certain assumptions about the parental materials are true. Some of the assumptions postulated by Hayman (1954) are: (1) diploid segregation; (2) no difference between reciprocal crosses; (3) independent action of non-allelic genes (no epistasis), and in the diallel cross; (4) no multiple allelism; (5) homozygous parents; (6) genes independently distributed between the parents. Of these assumptions, some can be accepted more easily than the others and it is well known that the assumptions, no epistasis and genes independently distributed between the parents are unjustifiable and biological unrealistic (Sokol and Baker, 1977; Baker, 1978). Fortunately, according to Hayman (1954), when failure of the hypotheses has been demontrated, it is possible to make estimates of components and to draw the (Wr, Vr) graph.

In present experiment, in order to test the validity of these assumptions postulated for the Hayman diallel analysis, a t-test of homogeneity of (Wr-Vr) over the parent arrays for the studied characteristics was performed firstly. Data estimated provided no evidence for rejecting the hypotheses, as shown in Table 3. Thus, an additive-dominance model with independence of the genes in action and in distribution was met to describe the two flag leaf characteristics evaluated. The estimates of components of variation and ratios between these components were, then, computed and a detailed genetic interpretation about the flag leaf characteristics was presented.

Table 3. Homogeneity test applied to the Hayman hypothesis for two flag leaf characteristics.

Characteristic	t-value[a]
leaf length	2.42
leaf width	0.28

[a] $t_{(4,\ 0.05)}=2.78$

Since the component E provides an estimate of environmental component of variation, the quantity E is pointed out and discussed firstly in the present paper. As shown in Table 4, the estimates of E for the flag leaf characteristics were all insignificantly different from zero, indicating that the variation due to block effects or the other unknown distrubing factors in the present analysis of rice was within the limits of accuracy set by the sampling error. the components of variaton of additive gene effects (D) and dominance gene effects (H_1, H_2, and h^2) were significant, indicating that both additive and dominance gene effects played an important role in differentiating the flag leaf characteristics among the parents, as shown in Table 4. However, the genetic mechanisms of two flag leaf characteristics were different. In detail, the dominance gene effects seemed to be more important than additive gene effects for flag leaf length. As to leaf width, on the other hand, the additive gene effects were greater than those of dominance, indicating that the additive gene effect played an more important role in conditioning the leaf width. These were further supported by relatively low and high narrow-sense heritabilities of the two leaf characteristics, respectively.

Table 4. Genetic components of variation and ratios between components of two flag leaf characteristics in the six-parent diallel cross of rice.

Component or ratio	Leaf length	Leaf width
D	8.3*	0.067**
F	− 4.8*	0.028**
H_1	22.0**	0.054**
H_2	18.1**	0.050**
h^2	−6.6*	0.068**
E	1.0	0.001
D-H_1	−13.7*	0.014**
$(H_1/D)^{1/2}$	1.6	0.92
$H_2/4H_1$	0.21	0.23
k_D/k_R	0.75	1.61
h^2/H_2	0.36	1.31
Heritability (narrow-sense)	0.22	0.69

**, * Significant at the 0.01 and 0.05 probability levels, respectively.

In the presence of unequal gene frequencies the sign and magnitude of the component F can be used to determine the relative frequencies of dominant to recessive alleles in the parents. If no genes exhibit dominance effects, or if the dominant and recessive alleles of each gene are distributed equally among the parents, the F value should be zero. If the increasing alleles are in overall excess, i. e. $u>v$ at the majority of loci, and the increasing allele is dominant at more loci than the decreasing allele, i. e. h^2 is positive at most loci, then the F value will be postitve. Similarly, if the decreasing alleles are in excess, i. e. $u>v$ at the majority of loci and the decreasing allele gene is dominant at more loci than the increasing allele, i. e. h^2 is negative for most loci, then, the F value will again be positive. Hence, the F will be positive whenever the dominant alleles are more frequent than the recessive alleles, and vice versa, i. e. negative F value indicates an excess of recessive alleles (Crumpacker and Allard, 1962; Mather and Jinks, 1971). In the present diallel experiment of rice, the signs of the F and h^2 values for flag leaf length were all negative and the magnitude of the two components were all significantly different from zero, thus indicating an excess of recessive alleles. Contrast to leaf length, both values of F and h^2 of leaf width were all significantly positive, thus, indicating an excess of dominance alleles. These were consistent with the values of k_D/k_R and $H_2/4H_1$ ratios, respectively. According to Hayman diallel theory, k_D/k_R, the ratio of the total numbers of dominant to recessive genes in all the parents, greater than 1 indicates an excess of dominant genes, and smaller than 1 suggests a predominance of recessive genes. On the other hand, the $H_2/4H_1$ ratio provides an estimate of the average frequency (uv) of positive (u, increasing) versus negative (v, decreasing) alleles in all the parents, where $u+v=1$. The value of $H_2/4H_1$ attains a maximum value of 0.25 when these frequencies are equal, i. e. $u=v=0.5$, $u\times v=0.25$. In the present case, the estimated values of $H_2/4H_1$ ratios for the two flag leaf characteristics were all less than 0.25 and, therefore, indicate that the positive and negative alleles were not equally distributed in the parents. Similarly, the values of k_D/k_R ratios for the two flag leaf characteristics were 0.75 (for leaf length) and 1.61 (for leaf width), suggesting an excess of recessive genes and an excess of dominant genes, respectively.

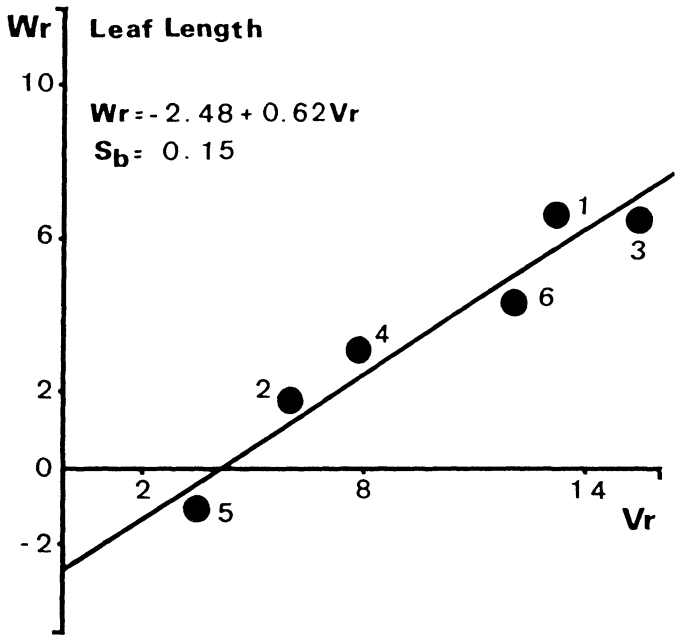
The ratio $(H_1/D)^{1/2}$ is an estimate of overall measure of dominance over all loci. If there is complete dominance, the value of $(H_1/D)^{1/2}$ will be 1.0; partial or incomplete dominance, between 0 and 1.0; and overdominance, greater than 1.0. In the present case, as shown in Table 4, The value of the $(H_1/D)^{1/2}$ ratio of flag leaf length was 1.6, greater than 1.0, suggesting an overdominance in differentiating flag leaf length among entries studied. However, the value of the $(H_1/D)^{1/2}$ of flag leaf width was 0.92, between 0 and 1.0, indicating a partial or incomplete dominance in conditioning flag leaf width. According to Baker (1978), when a failure of the assumption, independent distribution of genes in the parents, was occurred, it will result in an overestimation of the average degree of dominance. Also. if the epistastic effects are important, the mean degree of dominance may be upwardly biased (Povilaitis, 1966).

The ratio h^2/H_2 is an estimate of the number of groups which control the characteristic and exhibit dominance to some degree. However, if the dominants differ in sign, the ratio

will be underestimated. Also, it provides no information about groups of genes exhibiting little or no dominance (Hayman, 1954; Povilaitis, 1966). It would appear from the present study that no major gene groups was involved in differentiating flag leaf length of rice and at least one major gene group could probably be expected in controlling leaf width of flag leaf (Table 4).

Genetic interpretation induced form diallel graph

The regression graph of covariance (Wr, the covariance between these offspring and their non-recurrent parents) and variance (Vr, the variance of all the offspring of the rth parent) of arrays in diallel crosses provides a useful means of assessing genetic relationship among homozygous parents. As Hayman (1954) and Mather and Jinks (1971) have shown, the regression graph of Wr on Vr prospectively provides information on three points. First, it supplies a test of adequacy of the model: in the absence of non-allelic interaction and independent distribution of the genes among the parents, as homogeneity test does. Second, given that model is adequate, a measure of average level of dominance is provided by the departure from the origin of the point where the regression line cuts the Wr axis. It is a partial (incomplete) dominance when the intercept is positive (the line lies above the origin); overdominancce when the intercept is negative; complete dominance when the regression line passes through the origin. Third, the relative position of the point (Wr, Vr) along the regression line indicates the distribution of dominant and recessive genes among the parents ; the point nearest the origin stem from the arrays derived from parents with most dominant genes and the point furtherest from the origin stem from arrays derived from parents with fewest dominant genes, i. e. with most recessive genes. In the present experiment, the graphical analysis of Wr on Vr for the flag leaf characteristics was given in Fig. 1. The slopes of regression lines of Wr on Vr for two leaf characteristics were both significantly different from zero but did not differ significantly from unity. The excellent unit-slope linearity demonstrated validity of the assumptions on which the method was based. This was highly consistent with homogeneity test, as shown in Table 3. However, the regression line of leaf length cut Wr axis fairly below the point of origin, indicating an overdominance on the average over all arrays. The regression line of leaf width, in contrast, cut the Wr axis about the point of origin, suggesting a partial or incomplete dominance. Regarding the distribution of dominant and recessive genes among the parents in differentiating leaf length, parents Rexmont and Lemont possessed mostly recessive genes; parent Taichung Sen 10 had predominantly dominant genes. On the other hand, in conditioning leaf width, parents Rexmont, Lemont, Toro II, and CI 9902 formed a group in which dominant genes predominated; parents Taichung Sen 10 and Guichow had mostly recessive genes. It is evident that the genetic mechanisms of two leaf characteristics were different from the point of view taken from degree of dominance and the distribution of dominant and recessive genes among the parents, as mentioned above.



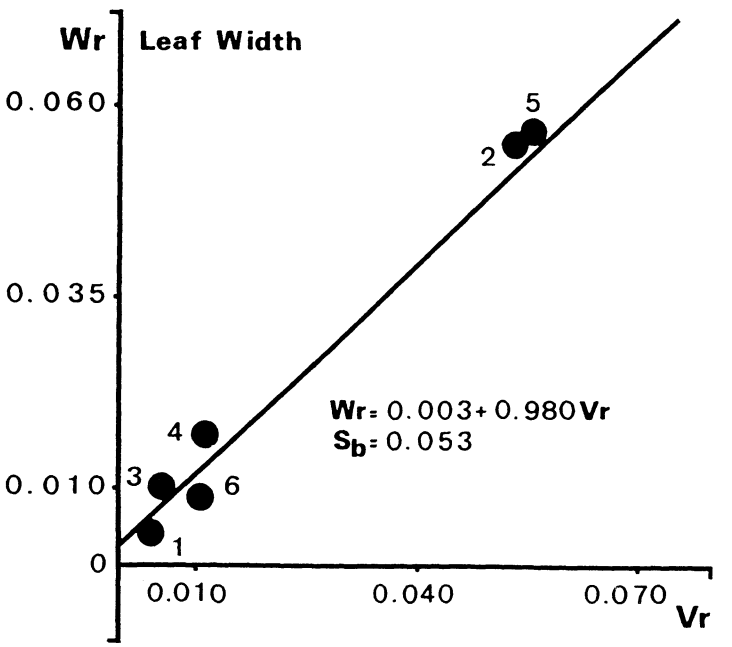


Fig. 1. The regression graph of Wr on Vr for two leaf characteristics of flag leaf of rice in the six-parent diallel cross. Parent code: 1-Rexmont; 2-Guichow; 3-Lemont; 4-CI 9902; 5-Taichung Sen 10; 6 -Toro II.

The last remaining information that can be obtained from the Wr and Vr values is the direction of the dominance. According to the theory of the diallel cross (Hayman, 1954; Mather and Jinks, 1971), since the relative values of (Wr+Vr) over arrays indicates the relative number of dominant to recessive alleles in the common parents of the arrays, we can see whether the distribution of dominant to recessive alleles is correlated with the phenotypes of the common parent by comparing the (Wr+Vr) value for each array with the mean of the common parent, i. e. comparing (Wr+Vr) (recessiveness-dominance indicator) with Yr (parental measurement). The correlation will be negative if the parents with a high score, i. e. those containing most increasing genes, have the lowest value of (Wr +Vr), i. e. containg most dominant genes, and the reverse is true. Furthermore, if the correlation is insignificant but there is a significant dominance, thus, the dominance will be ambidirectional. Hence, we can deduce whether or not the increasing or decreasing alleles are the dominant alleles. In short, the recessive (decreasing) genes must be mostly positive when the correlation coefficient (r) between (Wr+Vr) and Yr is significantly positive; the dominant (increasing) genes are positive when the r is significantly negative; when the r is insignificant, equal proportion of the dominant genes are positive and negative, i. e. ambidirection dominance. In the present study, the correlation coefficients between (Wr+ Vr) and Yr were all negative and significantly differed from zero only for leaf width. This might infer that the direction of dominance for increasing leaf length was ambidirectional, and the increase in dominance apparently was associated with higher performance of leaf width of the plants on an average of the parents.

The standardized deviation graphs of (Wr+Vr) and Yr, the relative positions of entries in respect to the parental performance and the recessiveness-dominance indicator, were graphically plotted in Fig. 2. As shown in Fig. 2, recessiveness is shown by points above the horizontal (parental performance) line and dominance by the points below this line; high parental performance is shown by points to the right of the vertical (recessiveness-dominance indicator) line and low parental performance by points to the left of this line. Thus, in differentiating leaf width, Taichung Sen10 and Guichow, located in the second quadrant, with mostly recessive genes had narrower flag leaves; Rxmont and Lemont, on the other hand, in the fourth quadrant, with the maximum number of dominant genes possesed relatively wider flag leaves; CI 9902 and Toro II possessing fewer dominant genes showed an intermediate leaf width of flag leaf. As to leaf length, a tendency (not significant) of recessiveness to be associanted with short leaf length and dominance to be long leaf length seemed to be observed. However, a undoubted fact, as shown in Fig. 2, that dominance with the longest (Taichung Sen 10, 28.57 cm), intermediate (Guichow, 24.68 cm), and the shortest (CI 9902, 20.10 cm) flag leaf length was indicated, i. e. an ambidirectional dominance in differentiating the leaf length of flag leaf among rice entries evaluated was inferred.

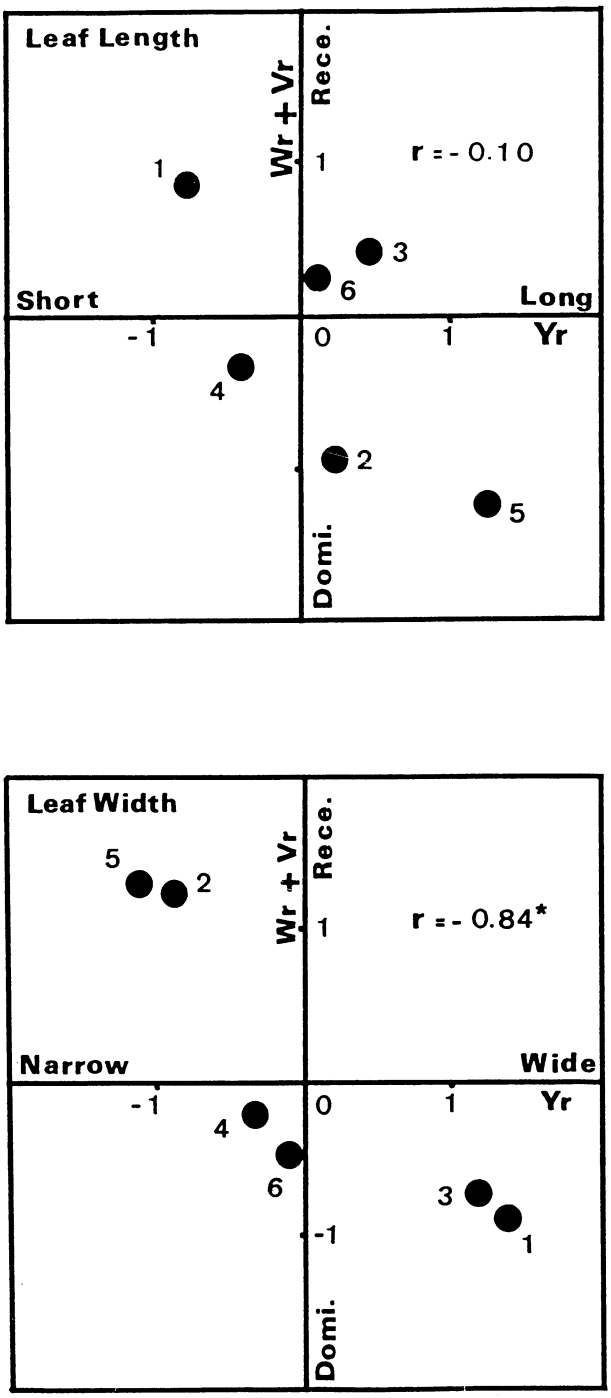


Fig. 2. The standardized deviation graph for two leaf characteristics of flag leaf of rice in the six-parent diallel cross with horizontal axis representing parental performance (Yr) and vertical axis representing the order of dominance (Wr+Vr). Parent code: 1-Rexmont; 2-Guichow; 3-Lemont; 4-CI 9902; 5-Taichung Sen 10; 6-Toro II.

REFERENCES

Baker, R. J. 1978. Issues in diallel analysis. Crop Sci. 18 : 533—536.

Chang, T. T., and C. C. Li. 1980. Genetics and breeding. pp 87—146. *In* : Rice : Production and Utilization. B. S. Luh ed. AVI Publ. Co., Inc., Westport, CT.

Crumpacker, D. W., and R. W. Allard. 1962. A diallel cross analysis of heading date in wheat. Hilgardia 32 : 275—318.

De Datta, S. K. 1981. Principles and Practices of Rice Production. John Wiley & Son, Inc., NY, 618pp.

Donald, C. M. 1968. The breeding of crop ideotypes. Euphytica 17 : 385—403.

Donald, C. R. 1987. An evaluation of ideotype breeding. Crop Sci. 27 : 1140—1146.

Hayman, B. I. 1954. The theory and analysis of diallel crosses. Genetics 39 : 789—809.

Jennings, P. R. 1964. Plant type as a rice breeding objective. Crop Sci. 4 : 13—15.

Johnson, L. P. V., and R. Aksel. 1959. Inheritance of yielding capacity in a fifteen-parent diallel cross of barley. Can. J. Genet. Cytol. 1 : 208—265.

Juliano, B. O. 1985. Production and utilization of rice. pp 1—16. *In* : Rice : Chemistry and Technology. 2nd ed., B. O. Juliano ed., Am. Assoc. Cereal Chem. St. Paul, MN.

Mather, K., and J. L. Jinks. 1971. Biometrical Genetics. Cornell University Press, Ithaca, NY., 382pp.

Mock, J. J., and R. B. Pearce. 1975. An ideotype of maize. Euphytica 24:613—623.

Povilaitis, B. 1966. Diallel cross analysis of quantitative characters in tobacco. Can. J. Gent. Cytol. 8 : 336—346.

Sokol, M. J., and R. J. Baker, 1977. Evaluation of the assumptions required for the genetic interpretation of diallel experiments in self-pollination crops. Can. J. Plant Sci. 57 : 1185—1191.

Tsunoda, S. A. 1959a. A development analysis of yielding ability in variety of field crops. I. Leaf area per plant and leaf area ratio. Japanese J. breeding 9 : 161—168.

Tsunoda, S. A. 1959b. A development analysis of yielding ability in variety of field crops. II. The assimilation-system of plants as affected by the form, direction and arrangement of single leaves. Japanese J. breeding 9 : 237—244.

Tsunoda, S. A. 1960. A development analysis of yielding ability in variety of field crops. III. The depth of green colour and the nitrogen content of leaves. Japanese J. breeding 10 : 107—110.

Tsunoda, S. A. 1962. A development analysis of yielding ability in variety of field crops. IV. Quantitative and spatial develpoment of the stem system. Japanese J. breeding 12 : 49—52.

Tu, Z. P., X. Z. Lin, Q. M. Huang, W. J. Cai, H. Y. Feng, and L. Y. Ye. 1988. Photosynthetic characterisation of rice varieties in relation to growth irradiance. Aust. J. Plant Physiol. 15 : 177—286.

Yoshida, S. 1972. Physiological aspects of grain yield. Ann. Rev. Plant Physiol. 23 : 437—446.

水稻劍葉長與寬之遺傳[1]

郭 益 全　　李 長 沛[2]

摘　要

鑒於美國稻與東方稻葉部性狀互有不同暨葉部性狀爲現代水稻育種計畫中極重要之性狀，爲擴大種原利用，一系列關於稻葉部性狀之遺傳研究已展開。本報告以包含美國稻與東方稻等六個水稻種原之全互交材料經藉 Hayman 氏之全互交理論及方法探討參試稻種原劍葉之長與寬的遺傳行爲。所得數據推論出該兩性狀雖受累加性基因及顯性基因所同時控制，但此兩性狀之遺傳機制則不盡相同。就劍葉之葉長而言，顯性基因效應顯著地大於累加性基因效應，平均顯性程度屬超顯性，顯性方向則呈兩向顯性。另方面，劍葉葉寬之遺傳機制則累加性基因效應顯著地大於顯性基因效應，平均顯性程度屬部分或不完全顯性，顯性方向則趨向寬劍葉者。

關鍵詞：遺傳、葉長與葉寬、劍葉、水稻。

1. 臺灣省農業試驗所　研究報告第 1713 號。
2. 本所農藝系副研究員及助理。臺灣省　臺中縣　霧峰鄉。